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GEO-COMMUNICATION AND WEB-BASED SPATIAL DATA INFRASTRUCTURE

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ABSTRACT

The purpose of geo-communication is to bridge the gap between reality and data sources on one side and decisions on the other side. This is achieved through several types of activities, where web-services and spatial data infrastructure play an important role. The introduction of web-services as index-portals based on geo-information has changed the conditions for both content and form of geo-communication. A high number of players and interactions as well as a very high number of all kinds of information and combinations of these characterize geo-communication carried out through web-services.

This paper discusses the relations between the different components of SDI and geo-communication as well as the impacts thereof. Discussed is also a model for the organization of the passive components of the infrastructure; i.e. legislation, collaboration, standards, models, specifications, web-services and finally the information. Awareness of the complexity is necessary, and structure is needed to make it possible for the geo-information community to pull together in the same direction.

Modern web-based geo-communication and its infrastructure looks very complex, and it will get even more complex! Therefore there is a strong need for theories and models that can describe this complex web in the SDI and geo-communication consisting of active components, passive components, users and information in order to make it possible to handle the complexity and to give the necessary framework.

THE PAPER'S BACKGROUND

The focus of this paper is the requirements driven or user driven development of Spatial Data Infrastructure (SDI), web-services and geo-communication. Most GIS-, cartography- and SDI-literature lacks theories, models and methodology for the systematic user requirement assessment, which comprises user awareness, situation awareness and capability awareness. This paper describes those relations on a general level through conceptual models. This paper is not a description of technical implementation methodology or prototyping.

INTRODUCTION

The role of geo-information and the distribution of geo-information have changed dramatically since the introduction of web-services on the Internet. In this context web-services perform the function as *index-portals* to further information. This index-function is based on geo-

information, e.g. maps. Maps are no longer an aim in themselves. Geo-communication is the combination of geo-information and its distribution through e.g. web-services.
The introduction of web-services as index-portals based on geo-information has changed the conditions for both content and form of geo-communication. A high number of players, interactions, a very high number of all kinds of information, and combinations of these, characterize web-services, where maps are only a part of the whole. This is a complete new situation compared to what the mapping-world was just a few years ago. This new situation demand new ways of modelling the processes contained in geo-communication.

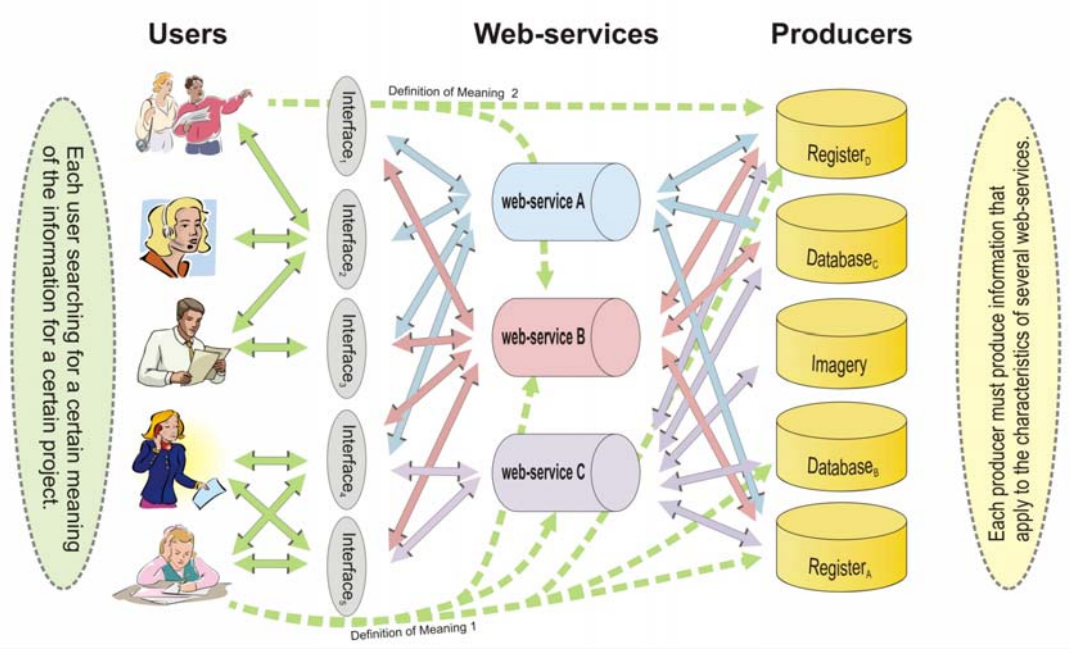

Figure 1: Geo-communication consists of several types of activities, where maps are a small part of it.
Web-services and spatial data infrastructure play an important role.

THE ELEMENTS OF GEO-COMMUNICATION

The purpose of any communication is to conduct the behaviour of the user! This is done by submitting relevant information, on the basis of which the user may decide, and hopefully he will be able to act. Decision demands supply of information, and is made on the basis of mental connections and integration with previous experience in the user's mind. Action is based on further mental activity and is part of the epistemology, which is outside the scope of this paper.
In order that the producer may communicate the necessary information to the user, the producer must as the very first activity analyse the phenomena of which the communication consists and be able to describe the result of this analysis in detail. The aim of the analysis is to identify and select that kind of information that is relevant to the user's contemplated activities. The purpose of the producer's analysis is to form a reasonable basis for the user for making a decision, which hopefully is followed by the according action *(Brodersen, 2005)*. Transmission of this kind of information, through any media, is part of geo-communication.

All together geo-communication describes a *value-chain* from reality to decision and the according action.
The user may want a basis for making decisions on a possible trip, i.e. a suggestion of an itinerary. For this purpose the user starts a web-service intended for this use. The user types the start point and the end point of the trip, date and time, and after a short time, he will receive a number of proposals for the itinerary. On this basis he will be able to make the decision, "Yes" or "No", to travel. The primary problem for the producer is to catch this problem and to deliver the relevant information containing this meaning. The secondary problem for the producer is to master the complex network of processes and their mutual dependencies.
Figure 2 illustrates such an example of travel planning. The process shown in the figure consists of geo-information and the spatial data infrastructure (SDI), i.e. the passive elements of geo-communication (plus a user). All processes shown in the illustration can be iterative. The illustration can be seen as a longitudinal section of the overall process. Compare also Figure 5 showing the cross section of the geo-communication.

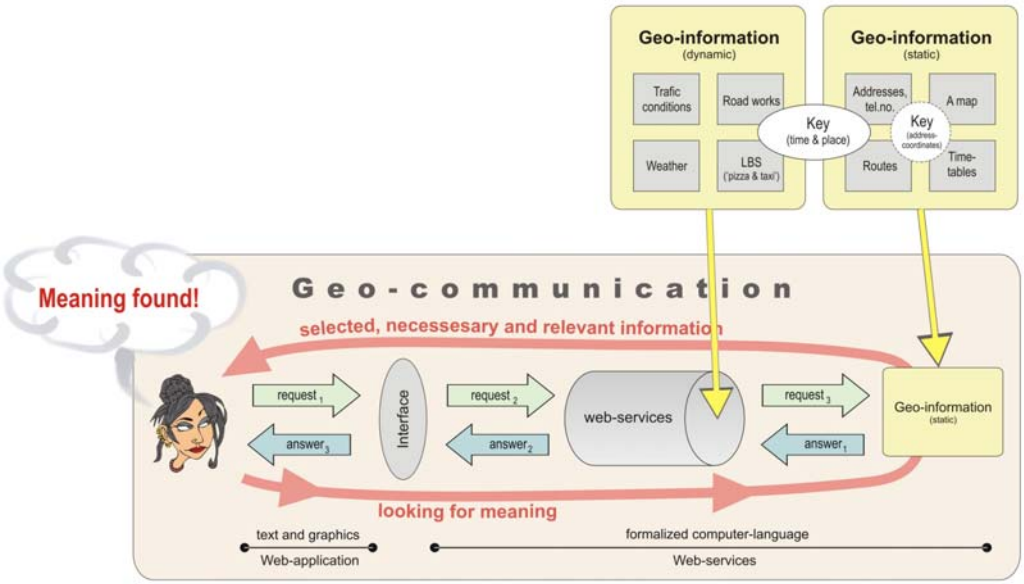

Figure 2: The user is looking for information enabling her to decide whether to take the trip or not.
The primary problem for the producer is to catch this problem and to deliver the relevant information containing this meaning.
The secondary problem for the producer is to master the complex network of processes.

Behind the interface of the web-service several things happen which the user need not to know about. On the basis of the web-services algorithms a number of questions are send to certain databases about certain geo-information, such as timetables, maps, road work, etc., which can be both static and dynamic.
It is important to note that the user does not ask for a certain timetable or a certain map, but only for the *meaning* of these in relation to the trip she wants to make. The *meaning* for the user is to have a basis on which first to make the decision to travel or not to travel, and if she decides to travel, then to know how to do it.

Communication is the sum of a number of transmissions. The above example in figure 2 is *not* just a transmission, because it is controlled if the potential users of the web-service actually do use the web-service and actually carries out the planned trips. Carrying out explorative visualization is also a kind of communication as the person discusses the preliminary results inside his mind. One way transmission or one-way communication happens almost never.

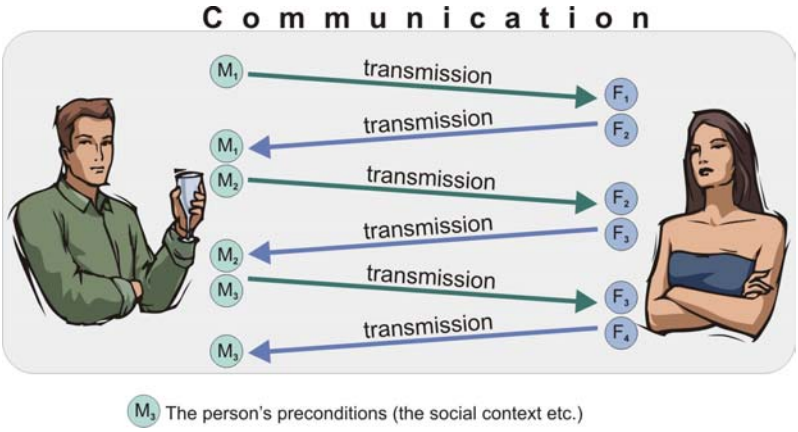

Figure 3: Communication is the sum of a number of transmissions.
In geo-communication is the 'feed-back transmission' established through quality control.
Or, transmission both ways happens when two people discuss explorative visualization.
Or, transmission both ways happen one person carries out explorative visualization and 'discusses it' inside his mind.

RELATIONS IN GEO-COMMUNICATION

Compared to the 'good old days' when maps were maps, geo-communication is characterized by new and complex structures.

- The service providers have influence on the content
- Several new producers have become active on the market
- The costs of the means of production have been reduced dramatically
- The requirements have increased grown
- There is no longer is a given relation between producer and end user, as it was the case in the 'good old days'
- In SDI is it necessary to make a distinction between active and passive components

Example: Up until approximately 1990 there was in Denmark *one* producer. This was due to the fact that the Geodetic Institute had a monopoly-like position in map-production, partly supported by legislation, and partly because of the extremely expensive means of production. The Geodetic Institute's production was linked strongly to the demands of the military, i.e. the military's definition of meaning of the geo-information was the basis for all production. More or less everybody else in the Danish society had to be satisfied with those military-oriented maps and other products. Since 1990 the monopoly has been removed. The law concerned was cancelled, and the costs of the means of production were reduced dramatically.

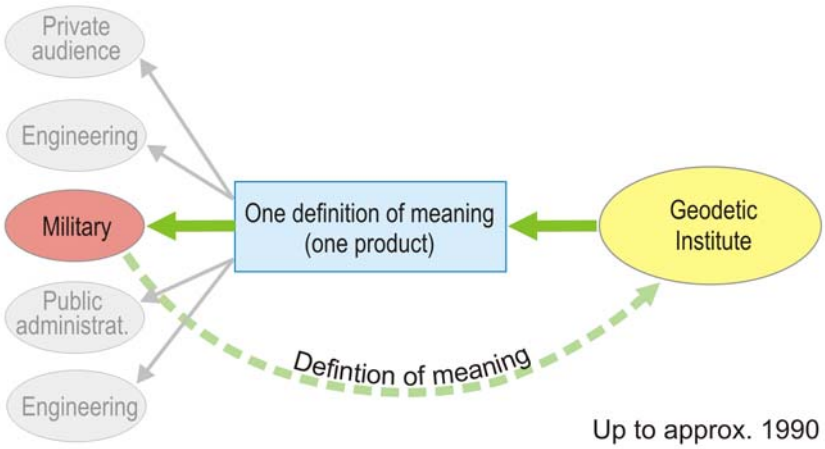

Figure 4: In Denmark up to approx. 1990:
One producer, one product, one definition of meaning, one simple form of distribution, and several users.

Today several producers are now active in producing geo-information, and several web-service-providers are carrying out the transmission of this geo-information to a huge number of users. This higher number of producers, service providers and users can be put into a diagram similar to the diagram in Figure 4 showing a part of the complexity of the new situation, see Figure 5, which is the same as Figure 1.

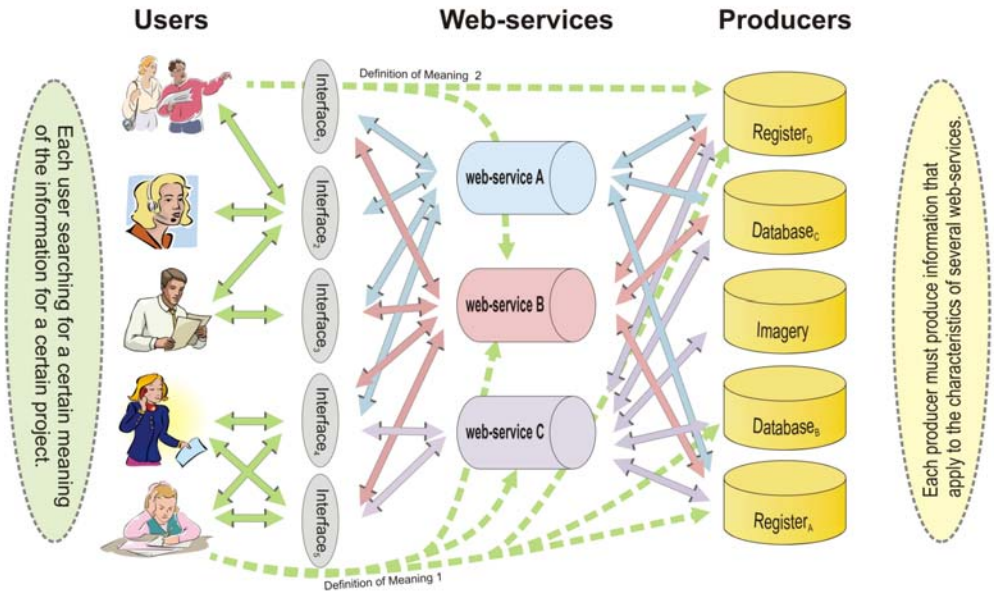

Figure 5: Today there are several producers of geo-information and several web-service providers carrying out geo-communication.
On top of the SDI a huge number of users are all trying to find that particular meaning of the geo-information that satisfies their particular needs.
Therefore the producers have to cope with several, different types of definitions of meaning.

The web in the Figure 5 illustrates a simple version of a web-based geo-communication community. The second point to be made here is that there is no longer only *one* definition of meaning with which everybody has to be satisfied. All users have the possibility to find a producer or a service provider who accepts to take care of *that* particular definition of meaning demanded by that particular user. The producers have lost control of the users' behaviour!

GEOGRAPHICAL INFORMATION SYSTEMS (GIS)

Geographic Information Systems (GIS) is often understood as the combination of *software, data and methods*, as the red dotted line in Figure 6 shows. This might well be so. However, we think that this no longer is sufficient to be able to understand the complexity of geo-communication based on SDI. Geo-communication should be seen and understood as consisting of GIS plus other elements, as Figure 6 illustrates.

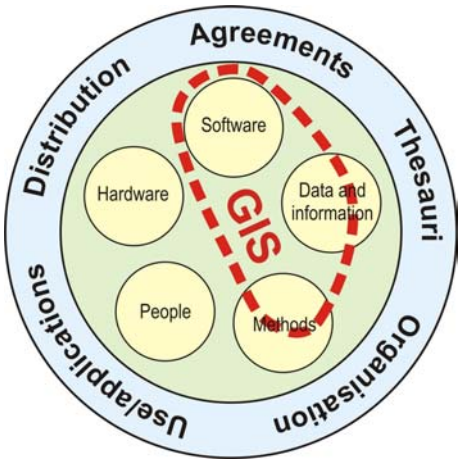

Figure 6: The diagram can be seen as a cross section of geo-communication. Compare also Figure 2 with the longitudinal section of the overall process of geo-communication.

THE ELEMENTS OF SPATIAL DATA INFRASTRUCTURE

Spatial Data Infrastructure (SDI) is the framework for geo-communication. Where geo-communication is the dissemination of geo-information through any available media for the purpose of making the meaning of information available, SDI is the framework that makes it possible to carry out geo-communication. Therefore some kind of overlapping can be identified. The geo-communication view-point is concerned with the meaning of the geo-information. The SDI view-point is concerned with the organisation and the services, systems etc. that make the transmission of geo-information possible. From an *organisational* view-point SDI can be seen as the combination of *organizations* and *public services*.
Infrastructure consists of the basic organization and public services. The basic organizations are the system according to which a company, organization, or other body is organized at the most basic level. Public services are the public systems, which facilities a country or region, and are necessary basis for economic activity, including power and water supplies, public transport, telecommunications, geo-communication, roads, and schools, etc.

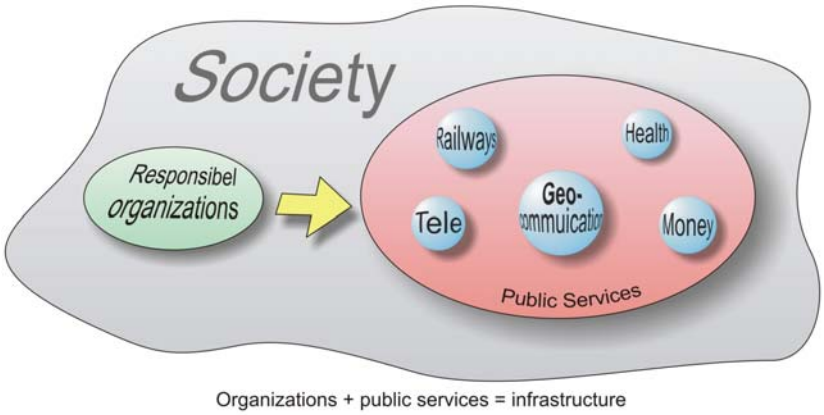

Figure 7: The combination of public services and the responsible organizations can be seen as the infrastructure of a society.
SDI is concerned with geo-communication and the respective responsible organizations.

THE ACTIVE COMPONENTS IN SDI

From an *activity* view-point SDI can be defined as a combination of active components and passive components. The active components in SDI are those organisations that get things running. The active components have the responsibility, and they must be active. Otherwise nothing will happen! The *active* components in SDI are:

- International Organizations like UN, NATO etc.
- Governments
- National Mapping Agencies
- Standardization bodies
- Custodians for various services
- Producers of geo-information

THE PASSIVE COMPONENTS IN SDI

The *passive* components in SDI are those documents that the active components have to produce to get the information about their activities distributed. These documents, the passive components, are the following, here presented in their mutual dependency. The mutual dependency is of iterative nature.

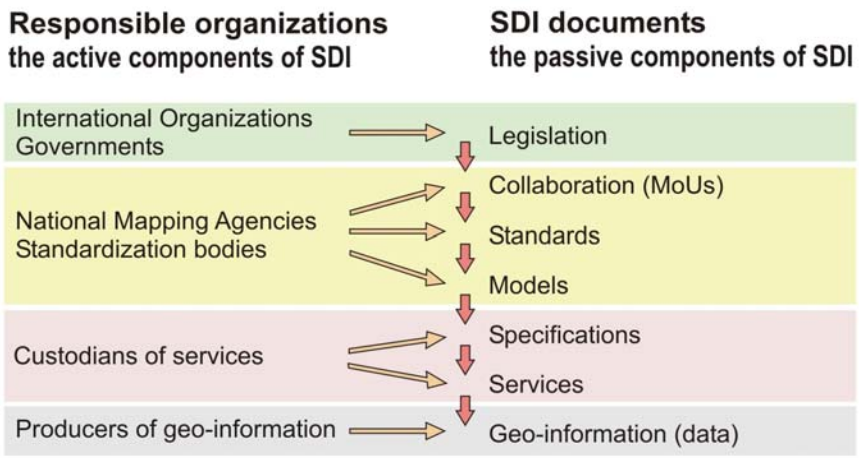

Figure 8: The active components in SDI are those organisations that get things running. The active components have the responsibility, and they must be active. The passive components in SDI are those documents made by the active components. The passive components are created to get the information distributed about the active components activities.

THE ELEMENTS OF THE PASSIVE COMPONENTS

The passive components are those documents containing and presenting the *results* of the activities of the active components. The passive components are dependent upon the activities in the organisations. Therefore they are called passive. These passive components are not active in themselves.

(1) *The legislation* is made by the organisations, the active components. The legislation must act on a general level taking care of:
- Enacting the framework for the deeper structures of SDI
- Setting the areas of *responsibilities*

(2) *Collaboration* (Memory of Understanding, MoU) are policy statements (position paper). Collaboration is based on the framework given by the legislation. Without this framework it is basically not possible to establish partnerships. Collaboration must act on a general level taking care of:
- Setting the area(s) of *interest*
- Establishing operational *partnerships* (within the framework of legislation)
- Inclusion of services as a full palette of joint government and commercial theatres
- Agreements upon the intention of sharing meta-information on services

(3) *Standards* are the necessary basis for activity within SDI. Standards are the logic and practical conclusions of the agreements made in (2) Collaboration. Collaboration is a *declaration of intent. Collaboration* does not say anything about *what* to work on. Standards define what to work on, and they define the activities. Standards are *general* and can therefore be used for several concrete projects, where a *specification* is concrete and valid for one project. A few examples of standards (of which a few are Danish standards):

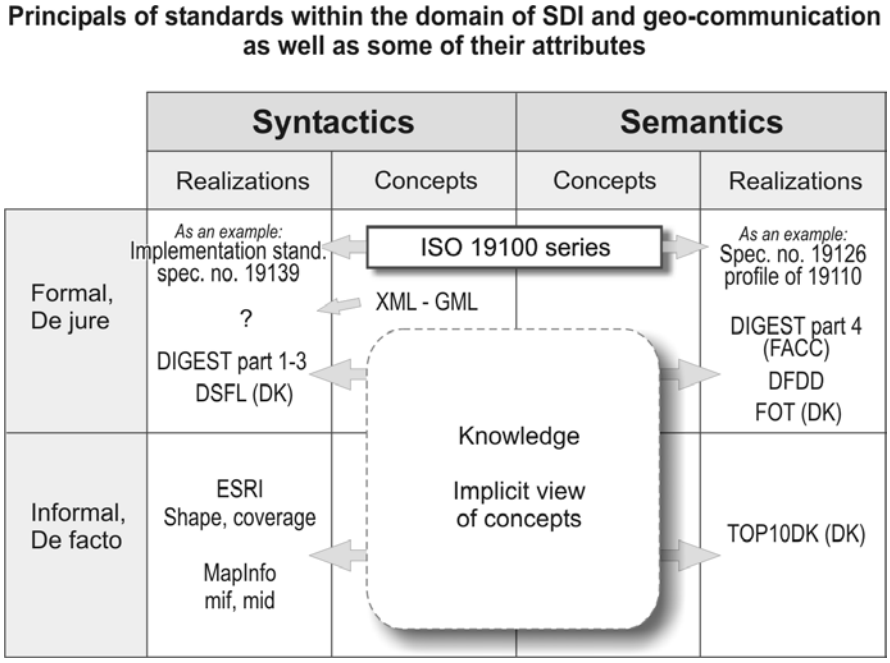

Figure 9: A few examples of standards.
Standards define what to work o, and are the necessary basis for activity within SDI.
Standards are general and can be used for several projects.

(4) *Models* describe how to use certain standards for a given project. Models bridge the gap between standards and specifications. Models describe:
- Value Model (Identification of content)
- Business process engineering (Information and resource flow, Requirements driven service development)
- System Use Case (Application schemas, General Feature models)
- The need for specifications (Implementation process)

(5) Specifications are descriptions of what has to be done in a certain project. A specification can e.g. specify that things have to be done in accordance with certain standards. A specification is concrete and valid for one given project; standards are general and valid for several projects. Specifications describe *rules* and *contents* for one given project:
- Categorizations and classifications of real world phenomena (features) within a standardized universe of discourse
- Definitions and descriptions of attributes on the level of the classified features
- Definitions of the information flow; sources, update strategy; components value assessment etc.
- Storage and security strategies
- Filtering and retrieval methodologies
- Strategies for multistage representation (incl. semantically and geometrical granularity and generalization)
- Symbolization strategy, design manuals and legend drafting

(6) *Services* are the concrete, practical set-up of the passive components no. 1 through 5. The passive components no. 1 through 5 can all be carried out on a piece of paper; nothing practical, actual has happened until here. Web-services bridge the gap between producer's databases and the users. Web-services are the technology making the use of geo-

information possible. Services establish the technology; i.e. the software, the hardware, the user-interfaces etc. Compare also Figure 1, 2, and 5.

(7) *Metadata and Information* is the 'fuel' to put into the machinery (the services) once the services have been created. Metadata and Information is *not* the technology! Metadata and Information are the actual, practical, concrete result of a certain production carried out in accordance with the characteristics of the services, with the specification, with the model, with the standard, with the MoU, and with the legislation. Information (data) is not products!

CONCLUSIONS

With the introduction of web-based geo-communication things have become most complex, compared to the 'good old days' when maps were maps. The user's decision and contemplated action is conditioned by the supply of geo-information, and the following mental connection and integration with previous experience in the user's mind. In order that the producer may communicate the necessary, relevant information to the user, the producer must be able to analyse the phenomenon of which the communication are based, and be able to describe the result of this analysis in detail. Transmission of this kind of information, through any available media, is part of geo-communication. All together geo-communication describes a *value-chain* from reality to the user's decision and the according action.

The framework for web-based geo-communication is the *spatial data infrastructure (SDI).* SDI consists of both active components and passive components. The active components get things happening. The passive components are the documents describing the results of the activities with the actives components. The passive components are the legislation, the agreements, the standards, the technology, the specifications and the information, which are the crucial elements of the infrastructure and with it, the necessary framework for web-based geo-communication. As there is a mutual dependency between all the components none of them can be left out. If just one component is missing, the impact is that the geo-communication is based on a non-systematic and non-conscious foundation.

Modern web-based geo-communication and its infrastructure is very complex, and it will get even more complex. Therefore there is a strong need for theories and models that can describe the 'web' of geo-communication and SDI in order to make it possible to handle the complexity and to give the necessary framework.

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Anders Nielsen is Senior Cartographer with the National Survey and Cadastre Denmark. Education as craftsmanship in cartography, topography, surveying, photogrammetry and remote sensing at the Geodetic Institute. Supplementary courses in these disciplines at the Technical University of Denmark. A large part of the career has been devoted to the photogrammetric survey of Greenland. Since the late 1990s full time occupation with geospatial standardization, primarily in the defense mapping domain.

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